

# Mesothelioma incidence in the neighbourhood of an asbestos-cement plant located in a national priority contaminated site

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## Abstract

**Background.** An epidemic of asbestos-related disease is ongoing in most industrialized countries, mainly attributable to past occupational exposure but partly due to environmental exposure. In this perspective, the incidence of pleural mesothelioma close to a former asbestos-cement plant in a national contaminated site was estimated.

**Methods.** The census-tracts interested by atmospheric dispersion of facilities in the contaminated site were identified. Two subareas with different estimated environmental asbestos impact were distinguished. An ecological study at micro-geographic level was performed. The standardized incidence ratios (SIR) for study area and the two subareas, in comparison with region and municipality were computed. The standardized incidence rate ratio (IRR) between the two subareas was computed.

**Results.** Mesothelioma incidence in the study area was increased: 46 cases were observed with respect to 22.23 expected (SIR: 2.02). The increase was confirmed in analysis considering only the subjects without an occupationally exposure to asbestos: 19 cases among men (SIR = 2.48; 95% CI: 1.49-3.88); 11 case among women (SIR = 1.34; 95% CI: 0.67-2.40). The IRR between the two subareas is less than one in overall population considering all age-classes and of 3 fold (IRR = 3.14, 95% CI: 0.65-9.17) in the age-classes below 55 years.

**Conclusions.** The findings indicate an increased incidence of pleural mesothelioma in the neighbourhood of asbestos-cement plant, and a possible etiological contribution of asbestos environmental exposure in detected risks.

## Key words

- mesothelioma
- incidence
- asbestos
- contaminated site
- environmental exposure

## INTRODUCTION

An epidemic of asbestos-related disease is still ongoing in most industrialized countries some decades after the termination of asbestos use in industries [1]. Occupational exposure in the past is the cause of most cases, but also domestic and environmental exposures, the latter due to residence near industrial asbestos sources, contribute to the overall asbestos-related disease burden [2, 3]. Furthermore, current asbestos exposure in Eastern European, Asian, African and Latin-American countries will cause a major number of new cases for a long time ahead [4]. There is general consensus about the need to map asbestos exposure and to implement

epidemiological surveillance of asbestos-related diseases, so as to estimate asbestos-related health impact in different contexts [1].

Italy has been a major asbestos producing country, a major industrial utilizer of asbestos and the current ongoing studies on occurrence of asbestos-related disease can provide elements of interest for countries that still use this material [5]. Epidemiological surveillance of pleural mesothelioma mortality [6, 7] and incidence [8] consistently showed significant increases in municipalities characterized by the presence of asbestos-cement plants. In some of these areas, epidemiological studies have detected significant mesothelioma risk caused by

residential proximity to asbestos-cement plants in the absence of occupational exposure [9, 10]. Several of these areas have been included among national priority contaminated sites, for which environmental remediation has been prescribed and only partially implemented [11]. In the meanwhile, no similar body of evidence of environmentally-induced mesothelioma cases, in areas close to steel industries or other industries where asbestos was present as an insulating agent, is currently available [12].

The purpose of the present study is to investigate the incidence of pleural mesothelioma in the districts of Naples municipality close to a former asbestos-cement plant located in the national priority contaminated site of Coroglio-Bagnoli. An ecological study at micro-geographic level was adopted.

## MATERIALS AND METHODS

The industrial area of Coroglio-Bagnoli in Naples municipality was included in the Italian national priority list of contaminated sites in 2000 (law 388/2000). Since the early years of the twentieth century a major steel plant, a cement factory, an asbestos-cement industry (Eternit) and a fertilizing agent manufacturing facility operated in the area. The contaminated site, such as defined by the law, includes an area of about 10 million square meters (Ministerial Decree of August 31<sup>st</sup> 2001). Currently, environmental remediation action is in progress. A heavily populated district in the neighbouring of the industrial area is present since the late Nineteenth Century.

Altogether, the industrial area includes 33 point sources (32 from steel plant and 1 from Eternit) and 14 areas of diffused emissions. These last are, in particular, the storage piles of coal and minerals used by the steel plant.

In the present investigation the environmental impact of asbestos fibres spread by Eternit plant is investigated, but it must be recalled that large amounts of asbestos were also used in the steel plant and, to a lesser extent, in the cement factory, where they were present as insulating agents and caused occupational exposure.

The asbestos-cement manufacturing facility used asbestos in the work cycle, and large quantities of this agent were constantly present. The Eternit asbestos-cement plant operated since 1939 through 1986. An Eternit plant occupational cohort study showed an increased mortality from asbestosis, pleural and peritoneal malignant tumours and from malignant tumour of lung in male workers operating since 1950 through 1986. The excess mortality was higher after 40 years latency period and among subjects with 10-19 years of exposure. Eighty-three percent of pleural and peritoneal malignant neoplasm cases were confirmed as having pleural malignant mesothelioma from the database of the Campania Regional Operating Centre (COR) of the National Mesothelioma Registry (ReNaM) [14]. No formal cohort study was performed in the steel plant, but the observation of 8 mesothelioma cases is strongly indicative of occupational asbestos exposure (source of information: Naples court room, Office of the Prosecutor).

In order to identify the area interested by the envi-

ronmental asbestos exposure to Eternit fibres, an atmospheric dispersion model was applied on the Eternit emissions, based on an estimate of diffuse fibres emission, deduced from the amount of material kneaded [15]. Meteorological data of the period of interest was not available, so the meteorological data of more recent years, namely 2007-2010, were considered. In addition, the dispersion model considered the orography of the area.

The atmospheric dispersion was estimated over an area of 6 km per 7.4 km and a mean concentration map was produced. Two subareas interested by different estimated concentrations of asbestos fibres spread by Eternit, were identified; given the unavoidable uncertainties associated with quantitative retrospective estimation of fibre exposure, a qualitative approach was adopted. The ratio between the mean concentrations of the two areas is about 10: the subarea 1, more distant from the plant, with lower impact of Eternit fibres, has an Eternit asbestos fibres impact on average 10 times lower than subarea 2, closer to the plant, with the highest impact. The subarea 2 is an oval-shaped area of about 4 square kilometres, with the downwind maximum distance from Eternit about 2.6 km long (*Figure 1*).

The residential area potentially interested by the atmospheric industrial emissions, was selected with the support of a Geographic Information System, and each census-tract was attributed to the corresponding subarea, on the basis of the geographical position of its own centroid.

The Registrar Office of Naples municipality provided the individual information of the subjects residing in the 628 census-tracts of the study area at 2001 census (no previous data were available). At 2001 census 174 682 subjects lived in the study area: 132 881 in subarea 1 and 41 801 in subarea 2.

By adoption of a record linkage procedure between the database of the resident population and those of the Regional Operating Centre (COR) of the National Mesothelioma Registry, pleural malignant mesothelioma cases resident in the study area at the time of diagnosis were identified. At the time of the study, the COR database included the cases of mesothelioma resident in Campania Region diagnosed in 2001-2007.

The rates of malignant pleural mesothelioma incidence in the study area were computed dividing the number of cases resident at diagnosis in the census-tracts included in the area by the corresponding population resident at 2001 census, multiplied by 7, the years of observation.

Regional and municipal reference rates were calculated on the basis of malignant pleural mesothelioma cases (COR database) and 2001 census population resident in the reference areas (multiplied by 7, as above); in calculation of municipal rate, the cases and the population resident in the study area were excluded from municipal rates. The age standardized incidence ratios (SIRs), and their 95% Confidence Intervals (95% CI), were computed for the overall population and for the two genders separately, by applying the indirect standardization method by use of STATA software, with respect to both regional and municipal population.

Thereafter, in order to assess the possible role of en-



**Figure 1**

The study area and the two subareas at different levels of asbestos fibres from Eternit (Naples municipality).

vironmental asbestos exposure, excluding the effect of exposure in occupational setting, we computed the SIRs excluding occupationally exposed subjects. In order to identify those subjects, the COR database information on individual asbestos exposure of mesothelioma cases was considered. In view of the limitations of individual exposure information in COR database, due to the low interview rate (36% of the cases resident in Naples municipality), the available occupational cohorts of asbestos–cement and steel plant present in the area were consulted.

Subsequently, all cases with an occupational exposure to asbestos classified as certain, probable or possible from COR database, following the ReNaM criteria (<http://www.ispesl.it/dml/leo/download/RenamGuidelines.pdf>), and from cohort records were excluded from the database of cases of the study area and were not included in further computation of municipal incidence rates.

Pleural malignant mesothelioma SIRs for the overall area and for each subarea with respect to the municipal rates (excluding the study area) were computed, ruling out the subjects with an occupational asbestos exposure as defined above. Finally, the ratio of the incidence rate (IRR) of subarea 2 to that one of subarea 1 was estimated.

## RESULTS

At 2001 census 174 682 subjects lived in the 628 census-tracts of the study area: 82 982 men and 91 700 women. 34 men and 12 women among them had a diagnosis

of pleural malignant mesothelioma (2001–2007), with mean age at diagnosis of 68.5 (68.9 in men and 67.3 in women). The annual crude rates were 5.9 among males and 1.9 in females  $\times 100\,000$  inhabitants.

In Campania Region, in the same period, 563 subjects had a diagnosis of pleural malignant mesothelioma; 139 of them were resident in Naples municipality.

The SIRs of the study area rate with respect to the regional and municipal (excluding study area) rates are shown in *Table 1*. The rate of municipal reference is based on 93 cases, because of the exclusion of cases resident in the study area. The incidence of mesothelioma in the study area showed significant increases in both genders with respect to the Regional rates (14.81 expected cases, SIR = 2.30 in men and 5.31 expected, SIR = 2.26 in women); with respect to the municipal rates the increase was statistically significant among men (14 expected cases and SIR = 2.42), but not among women (8.19 expected, SIR = 1.47). From COR database, 18 pleural malignant mesothelioma cases of the 93 cases resident in municipal reference area (Naples municipality, excluding the study area) had an occupational exposure to asbestos, defined as certain, probable or possible (54.5% of respondent mesothelioma cases). By consulting the two occupational cohorts, no other occupationally exposed case was detected. The municipal reference rates, thus, were based on 75 cases (40 men and 35 women) without documented occupational exposure to asbestos.

Out of the 46 pleural malignant mesothelioma cases resident in the study area, 17 were interviewed (37%); 16 of them presented an occupational asbestos exposure, as defined by ReNaM: 8 (all men) worked in the steel plant and 5 (among whom one woman) in Eternit, all with a certain occupational exposure, and other 3 cases with an occupational exposure to asbestos detected as probable (two cases) or possible (one case). Thus, in this phase, the analysis considered the 30 cases resident in the study area without a documented occupational exposure to asbestos.

The age-class and gender distribution of the cases without a documented occupational asbestos exposure, as above defined, is described in *Table 2*.

In the analysis excluding subjects occupationally exposed to asbestos, 30 cases were observed in the study area with respect to 17.8 expected on the basis of reference rates. As described in *Table 3*, the overall study area and subarea 1 showed an increase among men with respect to the municipal rates (SIR = 2.48, 19 observed cases, and SIR = 2.76, 16 observed, respectively), while the increases among women were not significant (SIR = 1.34, 11 observed cases; SIR = 1.05, 8 observed). Subarea 2, with higher estimated exposure to asbestos fibres spread by Eternit, showed non statistically significant increases with respect to the municipal incidence rate, among both genders (*Table 3*). This result may be due to small size of the population and the low number of expected cases. The ratio of incident rate subarea 2 to that one of subarea 1 rate (IRR) showed a defect in the overall population, considering all age-classes (IRR = 0.77; 95% CI: 0.28–1.67), but was of 3 fold (IRR = 3.14, 95% CI: 0.65–9.17) in the age-class below 55 years.

**Table 1**

Malignant pleural mesothelioma incidence in the study area, with respect to the regional and municipal rates (2001-2007)

Study area vs Campania Region				
Gender	Observed	Expected	SIR*	95% CI*
Men	34	14.81	2.30	1.59-3.21
Women	12	5.31	2.26	1.17-3.95
Overall	46	20.12	2.29	1.67-3.05
Study area vs Naples municipality (study area excluded)				
Gender	Observed	Expected	SIR*	95% CI*
Men	34	14.05	2.42	1.68-3.38
Women	12	8.19	1.47	0.76-2.56
Overall	46	22.23	2.07	1.52-2.76

\* SIR: standardized incidence ratio; CI: confidence intervals.

**Table 2**

Gender and age-class distribution of malignant pleural mesothelioma cases, ruling out documented occupationally exposed subjects, by subareas (2001-2007)

Subarea 1		Age-class						
	45	50	55	60	65	70	75+	tot
Men	1	2	0	3	1	3	6	16
Women	0	0	1	0	3	1	3	8
Total	1	2	1	3	4	4	9	24
Subarea 2								
Men	0	1	1	0	0	0	1	3
Women	2	0	0	0	1	0	0	3
Total	2	1	1	0	1	0	1	6

**Table 3**

Malignant pleural mesothelioma incidence, with respect to the municipal rates (study area excluded), ruling out the cases with a documented occupational asbestos exposure (2001-2007)

The overall study area					
Gender	Population (2001 Census)	Observed (2001-2007)	Expected	SIR*	95% CI*
Men	82 982	19	7.65	2.48	1.49-3.88
Women	91 700	11	8.19	1.34	0.67-2.40
Total	174 682	30	17.77	1.69	1.14-2.41
Subarea 1 "less exposed to Eternit fibres"					
Gender	Population (2001 Census)	Observed (2001-2007)	Expected	SIR*	95% CI*
Men	63 160	16	5.79	2.76	1.58-4.48
Women	69 721	8	7.63	1.05	0.45-2.07
Total	132 881	24	13.42	1.79	1.14-2.66
Subarea 2 "more exposed to Eternit fibres"					
Gender	Population (2001 Census)	Observed (2001-2007)	Expected	SIR*	95% CI*
Men	19 822	3	1.86	1.61	0.33-4.71
Women	21 979	3	2.48	1.21	0.25-3.53
Total	41 801	6	4.34	1.38	0.51-3.00

\* SIR: standardized incidence ratio; CI: confidence intervals



## DISCUSSION AND CONCLUSIONS

The present study provides the estimation of pleural malignant mesothelioma incidence in a territory close to a national priority contaminated site, that included an asbestos cement plant. A micro-geographic approach was used, considering the census-tracts interested by the air dispersion impact of the facilities present in the contaminated site. Focus of the present study was exposure to asbestos fibres spread by the asbestos-cement plant, even if environmental contamination of asbestos-fibres spread by the steel foundry present in the industrial area can't be excluded.

In view of the time-window of diagnosis of mesothelioma cases considered in the present investigation and of the latency period of the disease, the corresponding etiologically relevant exposures might have shown a peak between 1955 and 1965.

The incidence rates of pleural malignant mesothelioma in the study area (5.9 among males and 1.9 in females x 100 000 inhabitants) were higher than the corresponding Italian national rates (3.49 for men and 1.25 for women per 100 000 inhabitants, in 2004, with a wide regional variability) [8].

Asbestos fibre concentration in ambient air close to asbestos-cement factories in Italy has been inadequately monitored in the past, when the factories were active. A recent study of asbestos fibre burden in the lungs of eight mesothelioma cases resident close to asbestos-cement plants in Piedmont and Apulia Regions and not occupationally exposed to asbestos, showed values ranging from 110 000 to 4 300 000 fibres per gram (f/g) of dry lung, with three cases over 1 000 000 f/g [16]. This finding supports the notion of an asbestos contamination of the living environment when the plants were operating.

Despite the weakness caused by the limited data availability, the present study represents an innovative approach in the epidemiological investigations on the health impact of the facilities present in a contaminated site and, in particular, where an asbestos cement plant operated: the geographic study design at small area level, constituted by the census-tracts, supported by an

atmospheric dispersion model may provide useful information in the context where individual studies are not feasible, and where the impact is conceivable in a well circumscribed and detectable area.

Moreover, the present investigation represents the first evaluation of the health status of the population resident close to Coroglio-Bagnoli contaminated site (in Naples municipality), which so far has never been investigated.

The present study detected an increased incidence of pleural mesothelioma in the study area, with respect to the Regional and Municipal rates; the limitation of information about individual asbestos exposure, due to the low interview rate in COR database, does not allow to exclude a role of occupational exposure in the increases of mesothelioma incidence in the study area. The excess incidence of mesothelioma in the study area, anyhow, is present also in the analysis excluding cases with documented occupational exposure to asbestos. The observed increased IRR in the population below 55 resident in the subarea closer to the asbestos factory might indirectly support the notion of environmental exposure early in life [17].

In any case, improvement of the Campania Region Mesothelioma Registry database as far as asbestos exposure is concerned, is warranted in order to properly assess the etiological role of environmental asbestos exposure.

The public health relevance of environmental asbestos exposure in Italian national priority contaminated sites has been stressed in the final report of the Governmental Conference on the asbestos and asbestos-related disease [18], and replication of the present study in other settings is foreseen.

## Conflict of interest statement

There are no potential conflicts of interest or any financial or personal relationships with other people or organizations that could inappropriately bias conduct and findings of this study.

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